

KARU

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ROHDE & SCHWARZ

Capacitance Meter

Type Karu

BN-510

BESCHREIBUNG

MP MASTER



MA21425

Instruction Book

CAPACITANCE METER

Type KARU

BN 510

ROHDE & SCHWARZ
SALES CO. (U.S.A.), INC.
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Note: Always quote the Type and Order Number (BN) in addition to the Serial Number (FNR.) of the set when asking for technical information and, in particular, when ordering repair parts.

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Table of Contents

1. Specifications 3

2. Uses 4

3. Description 5

4. Preparation for Use 7

4.1 Adapting the Set to the AC Supply and Switching On 7

4.2 Zero-Setting of the Capacitance Scale 7

4.3 Connection of Capacitors 8

5. Operating Instructions 9

5.1 Measuring Capacitors with an Accuracy of $\pm 1\%$ 9

5.2 Measuring with High Accuracy by means of a Standard Capacitor 9

5.3 Adjusting Capacitors to a Tolerance of $\pm 1\%$ 10

5.4 Measuring Capacitors Larger than 10 μf 10

6. Replacement of Valves 11

7. Table of Replaceable Parts 12

Guarantee 16

Circuit Diagram of Type KARU

548
2

1. Specifications

Measurement range	0 to 10 μf
in 6 sub-ranges	0 to 100 μf 100 to 1000 μf 1000 to 10,000 μf 0.01 to 0.1 μf 0.1 to 1 μf 1 to 10 μf
Accuracy	$\pm 1\%$ $\pm 0.5 \mu\text{f}$
Measuring frequency	175 to 1.5 kc
depending on above ranges . . .	175 to 85 kc 85 to 30 kc 30 to 10 kc 50 to 15 kc 15 to 5 kc 5 to 1.5 kc
Measuring terminals	2 knurled screw terminals (spacing 30 mm, ID of socket 4 mm, one terminal connected to chassis)
Power supply	115/125/220/235 v $\pm 10\%$ 47 to 63 cps (10 va)
Valves, etc.	1 valve 6 H 6 1 valve 6 SN 7 1 miniature glow lamp 220 v 1 0.1-amp fuse (with 220/235 v)
Dimensions	268 x 227 x 226 mm (R&S Standard Cabinet 35)
Weight	7 kg

2. Uses

The Capacitance Meter Type KARU permits the direct measurement of the capacitance of capacitors in the range 0 to 10 μf , with an accuracy of $\pm 1\%$ $\pm 0.5 \mu\text{f}$ in all six ranges. Use is made of the resonance method. With the adjustment to resonance completed, the capacitance value of the capacitor under test can be read directly in micromicrofarads or microfarads.

It is possible to measure, e.g., wiring capacitances of a few micro-microfarads as easily as capacitors of a few microfarads. Owing to the relatively low measuring frequency of 175 kc maximum, the set is also useful for the measurement of the capacitance of greater lengths of cable.

Within normal limits, the dissipation factor of the capacitor under test does not affect the accuracy of the measurement. However, the set does not lend itself to checking electrolytic capacitors. For this purpose we would recommend our Microfarad Meter Type KZT BN 5400, covering 0.01 to 5000 μf .

The electrical and mechanical properties of the Type KARU allow its use in laboratories and test departments. It will withstand rough handling in work-shops or outdoor work. It is provided with a rugged steel cabinet, and a removable steel lid protects the front panel during transportation.

Unlike bridge type meters, the operation of the Type KARU is very simple so that even non-technical personnel will be able to measure rapidly, e.g., when adjusting or sorting capacitors. The reading can never be taken from a false scale as only the scale associated with the respective sub-range is visible.

Due to the sharp resonance indication, the set makes possible highly accurate comparison measurements with an accuracy of about 0.1%. This feature is of particular importance, e.g., in the production of standard capacitors or adjustment of multi-gang capacitors for tracking.

3. Description

Fig. 1 shows the simplified circuit diagram of the set. Its main components are an oscillator, a test circuit and an indicator section. One system of the duo-triode RÖ1 operates as the oscillator valve. Fundamentally, the circuit operates as follows: The capacitor under test C_x and the test circuit coil L_t contained in the set form a parallel resonant circuit loosely coupled to the oscillator coil L_o through the coupling coil L_k . The inductance of L_t and the capacitance of the zero-setting capacitor C26 (including the wiring capacitances) are fixed. If the frequency of the oscillator is varied until it equals the resonant frequency

$$f_r = \frac{1}{2\pi \sqrt{L_t (C_x + C26)}}$$

of the test circuit, then

$$C_x = \frac{1}{(2\pi f)^2 L_t} - C26.$$

The scale of the variable capacitor C8 of the oscillator is not calibrated in frequencies but directly in terms of capacitance to permit direct reading of C_x after the adjustment for resonance has been completed. The trimmer C26 serves the zero adjustment (in the lowest measurement range) even with the leads connected or with the test clamps used.

For resonance indication, the resonance voltage developed across the test circuit is applied to a conventional voltage multiplying circuit made up of the two diode sections of RÖ2 while the meter is controlled by the rectified voltage developed across the load resistor R8. The voltage divider R1-R2-R3-R4-R5 has been so adjusted that, with the instrument off resonance and the control INDICATION fully advanced, the needle deflects only up to the beginning of the mark MEASURING.

With increasing resonance voltage and (positive) rectified voltage from R8 applied to the grid of the meter valve, the anode current of the latter rises first linearly within the range of indication MEASURING and subsequently about logarithmically within the range of indication SEARCHING since the positive voltage developed across R8 overcompensates for the negative basic grid bias and produces a grid current. In this way,

each position of the control INDICATION covers a relatively wide range of indication while nevertheless a sharp resonance indication is obtained for accurate measurements.

If the range of indication is not sufficient when tuning for resonance, e.g., when checking a capacitor of very low loss it is just necessary to reduce the sensitivity by backing off the control INDICATION until tuning is possible in the range MEASURING.

The oscillator possesses a separate tank circuit for each of the six capacitance ranges. See circuit diagram in Fig. 2. The change-over switch of these six tank circuits is provided with a segment short-circuiting the five tank circuits that are not cut in. The occurrence of dips due to the natural resonance of the tank circuits that are not cut in is thus eliminated. Pulling effects between the test circuit and oscillator are prevented by loose coupling. The frequency ranges listed under "Specifications" correspond to the six capacitance ranges.

The measuring frequency does not decrease steadily as the capacitance of C_x increases but jumps from 10 to 50 kc (with $C_x = 10,000 \mu\text{f}$) when one passes from the third to the fourth measurement range. Here, a change-over is made from the test circuit coil L7 to the test circuit coil L8.

A cord drive ensures that the six-scale linear cylinder dial rotates positively with the measurement range switch. The scale window has been made so large only that no scale other than that of the range adjusted for is visible from the outside. Thus the ranges cannot be mixed up. To eliminate backlash the variable capacitor drive is provided with scissors gears. No-parallax reading is ensured by the double hair-line on the glass cursor.

The power section of the set is arranged for the four a-c supply voltages of 115, 125, 220 and 235 v. A selenium rectifier, instead of a valve, is incorporated for the anode supply in order to produce as little heat as possible, i.e. to achieve maximum frequency stability. This precaution as well as high-grade r-f components in part subjected to artificial aging guarantee that the frequency is maintained at $\pm 0.5\%$ over a long period of operation and, consequently, that the accuracy of the capacitance measurement remains $\pm 1\%$. The power drain from the a-c supply is about 10 va only. Thus it is possible, e.g. for outdoor work, to feed

the set also from a battery by means of a small vibrator pack. The waveform does not affect the accuracy if the level is maintained.

The cabinet of the set is of steel. The set has a hinged carrying handle on its top; a steel lid is put over the front panel for its protection. The four little cups on the top prevent a set which has the same bottom dimensions and is put on the Type KARU from sliding off.

4. Preparation for Use

4.1 Adapting the Set to the AC Supply and Switching On

The set leaves the factory adjusted for 220 v. To adapt it for 115, 125 or 235 v, loosen the screws at the four corners of the front panel, remove the chassis from the cabinet and insert a suitable fuse into the labelled clips on the fuse strip. Use a 100-ma fuse for 220 and 235 v and a 250-ma fuse for 125 and 115 v (0,25 C DIN 41571).

The small toggle switch over the power-cord entrance is the power switch. The glow lamp above it is the voltage indicator.

4.2 Zero-Setting of the Capacitance Scale

This adjustment should be checked after a warm-up period of a few minutes and corrected, if necessary. However, it is of importance only in the measurement of small capacitances and serves to bring the wiring capacitance to the value required for the calibration. Switch to the range 0 to 100 μf , set the glass cursor exactly to 0 μf , turn the knob INDICATION first against the right stop and then adjust the slotted screw recessed at the right of the test terminals for maximum deflection on the meter (resonance). Now back off the control INDICATION until the pointer deflection is in the range MEASURING and once more tune exactly to resonance by means of the zero-setting trimmer. When the cursor moves over the capacitance scale, the resonance indication should hence be a maximum at the division 0 μf . The capacitance calibration thus includes the test terminals.

4.3 Connection of Capacitors

Capacitors provided with leads should be directly connected to the terminals. In this case connect the earth pole of the capacitor to the r.h. test terminal identified by the earth symbol. Otherwise, shunt and body capacitances also would be measured and thus an error introduced especially when checking small capacitances. With a tubular capacitor, for instance, the earth pole is the outer layer, with paper capacitors it is the side mostly identified by a ring and with conventional r-f variable capacitors it is the rotor.

In production testing of small capacitors, it is too painstaking and time-consuming to fix the latter in the screw terminals. The best method is to use two sorting clamps of hard, silvered sheet metal, secured to the screw terminals. These clamps introduce a small capacitance which is to be considered in accurate measurements of small capacitances. Allowance for this can be made in two ways:

Either by measuring the capacitance of the clamps before connecting the capacitor and then subtracting the result from the total reading or by correcting the zero-setting with the sorting clamps attached, as outlined under 4.2, then the capacitance calibrated includes the clamps.

If two connecting leads are needed, e.g., in the measurement of built-in capacitors, the correction of the zero-setting as necessary on account of these leads and by referring to 4.2 is feasible only for a limited lead capacitance. In the event that the capacitance range of the zero-setting trimmer is insufficient, first determine the capacitance of the capacitor plus connecting leads; next measure the self-capacitance of these leads without altering their position and subtract the result from the total capacitance.

In the measurement of large capacitors, it is necessary to use leads of minimum resistance to keep down the additional dissipation factor. Two connecting leads of together $1\ \Omega$ would cause an additional dissipation factor of about 3% in the case of a capacitor of $1\ \mu\text{f}$. If the dissipation factor of the capacitor itself is great, a reduction of the accuracy might ensue from it on account of the minor sharpness of resonance.

5. Operating Instructions

5.1 Measuring Capacitors with an Accuracy of $\pm 1\%$

First turn the sensitivity control marked INDICATION against the right stop. The pointer will then deflect up to the beginning of the range MEASURING. If the capacitance of the capacitor under test is roughly known set the measurement-range switch to the proper range and slowly move the cursor until the deflection of the instrument pointer increases and reaches a maximum. If necessary, slightly back off the control INDICATION so as to permit tuning to maximum, i.e., to the highest resonance deflection. The range MEASURING of the meter permits the most accurate adjustment to the resonance hump to be made. To do so, back off the control INDICATION while improving the adjustment to resonance at the same time so that tuning is possible in this sensitive range of indication. When taking the reading be sure that the two hair-lines of the cursor coincide. If no rough estimation of the capacitance value to be determined is possible it is recommended to begin finding the resonance point in the first range 0 to 100 μf (with the highest measuring frequency) to preclude erroneous tuning to a harmonic when a capacitor of a higher dissipation factor is measured.

5.2 Measuring with High Accuracy by means of a Standard Capacitor

Due to the sharp resonance indication it is possible to measure much more accurately by means of a continuously variable capacitance standard. In the ranges from 0 to 1 μf , the Type KARU itself permits comparative measurements with an accuracy of $\pm 0.1\%$. For example, the following methods may be employed:

- (a) Connect C_x and accurately adjust for resonance within the range MEASURING of the Type KARU.

Substitute the standard capacitor C_S for C_x and adjust C_S until resonance is accurately restored; C_x then equals C_S .

- (b) Connect the standard capacitor, adjust it for a capacitance $C_S > C_x$ and accurately tune for resonance on the Type KARU.

Connect C_x across the capacitance standard and reduce the capacitance of the latter until the Type KARU again indicates resonance; then $C_x = C_{S\text{max}} - C_{S\text{min}}$.

(c) Connect C_x across the standard capacitor adjusting the latter for its minimum capacitance C_{Sb} ; next tune accurately for resonance on the Type KARU.

Disconnect C_x and increase the capacitance of the standard capacitor to C_{Se} until the Type KARU again indicates resonance accurately; then $C_x = C_{Se} - C_{Sa}$.

5.3 Adjusting Capacitors to a Tolerance of $\pm 1\%$

First find out whether the capacitance of the capacitor is too small or too large. Next set the Type KARU accurately to the desired capacitance and achieve the necessary capacitance change by a parallel connection or, in the case of paper capacitors, by unrolling until the Type KARU shows maximum deflection. If unrolling of the paper strips is possible only after a heat treatment the final measurement should be made after the capacitor roll has cooled off again.

The capacitance of ceramic tubular capacitors can be reduced, e.g., by scraping or grinding off the coating, using a suitable scraper or a fine-grained, quickly rotating grinding disc. In doing so, be sure that the contours at the scraped or ground edges are smooth, i.e., not frayed.

5.4 Measuring Capacitors Larger than 10 μf

Using a capacitor C_{aux} whose capacitance is still measurable directly at the upper end of the highest range, 1 to 10 μf , it is also possible to measure capacitors of 10 to about 100 μf . For C_{aux} choose a low-loss capacitor of 10 μf ; in this case, C_x may also be an electrolytic capacitor. Connect C_x in series with C_{aux} and determine the capacitance C_s of this series connection. C_x then results from

$$C_x = \frac{C_{aux} \cdot C_s}{C_{aux} - C_s}$$

However, if the value of C_x increases, the measurement accuracy decreases very quickly. For example: with $C_{aux} = 10 \mu\text{f}$, a capacitor of 100 μf can be measured only with an accuracy of about $\pm 10\%$.

6. Replacement of Valves

The two valves are readily accessible after the chassis has been removed from its cabinet, and they can be replaced without affecting the measurement accuracy. After replacement of the valve R61 (6 SN 7) it may become necessary to readjust the indicator section until the instrument pointer deflects roughly up to the beginning of the range MEASURING with the control INDICATION against the right stop.

To correct the adjustment, disconnect the line running from R7/C22 to the grid from the latter and insert a d-c voltage source (e.g. a battery) of 25 v between R7 and the grid, connecting the positive terminal to the grid. Now turn the control INDICATION against the right stop and rotate the control R2 for a pointer deflection to the arrow-head of the scale. Next remove the d-c voltage source, reconnect the grid lead and, adjusting the control R4, bring the pointer to the beginning of the range MEASURING. There is interaction between these two adjustments; hence it will be necessary to repeat the entire adjustment once or twice. The final adjustment is the one with R4. The two slotted-shaft controls are accessible in the interior of the set.

7. Table of Replaceable Parts

Ref. No.	Designation	Ratings	R&S Stock No.
C1	Capacitor, synth. foil	10,000 μmf /250 v	CKS 10 000/250
C2	Capacitor, synth. foil	750 μmf /500 v	CKS 750/500
C3	Capacitor, synth. foil	1250 μmf /500 v	CKS 1250/500
C4	Capacitor, synth. foil	750 μmf /500 v	CKS 750/500
C5	Capacitor, synth. foil	1000 μmf /500 v	CKS 1000/500
C6	Capacitor, synth. foil	750 μmf /500 v	CKS 750/500
C7	Capacitor, synth. foil	500 μmf /500 v	CKS 500/500
C8	Capacitor, variable	$\Delta C = 1030 \mu\text{mf}$	CD 8527
C9	Capacitor, ceramic	20 μmf	CTR 20
C11	Trimmer, disc	4 to 20 μmf	CV 924
C12	Trimmer, disc	4 to 20 μmf	CV 924
C13	Trimmer, disc	4 to 20 μmf	CV 924
C14	Trimmer, disc	4 to 20 μmf	CV 924
C15	Trimmer, disc	4 to 20 μmf	CV 924
C16	Trimmer, disc	4 to 20 μmf	CV 924
C17	Capacitor, ceramic	160 μmf	CTR 160
C18	Capacitor, ceramic	30 μmf	CTR 30
C19	Capacitor, MP	4 μf /160 v	CMR 4/160
C20	Capacitor, synth. foil	10,000 μmf /125 v	CKS 10 000/125
C21	Capacitor, synth. foil	10,000 μmf /125 v	CKS 10 000/125
C23	Capacitor, synth. foil	1000 μmf /500 v	CKS 1000/500
C22	Capacitor, synth. foil	1000 μmf /500 v	CKS 1000/500
C25	Capacitor, synth. foil	1000 μmf /500 v	CKS 1000/500
C26	Capacitor, air	3 to 13 μmf	CV 61110
G11	Rectifier, power	250 v/30 ma	GNB 14/250/30

48
12

Ref. No.	Designation	Ratings	R&S Stock No.
I1	Ammeter, moving-coil	1 ma	IP 072/1 ma
K1	Cable, connection		LK 303
L1	Coil		F 510 - 3.2
L2	Coil		F 510 - 3.3
L3	Coil		F 510 - 3.4/1
L4	Coil		F 510 - 3.5/1
L5	Coil		F 510 - 3.6/1
L6	Coil		F 510 - 3.7/1
L7	Coil		F 510 - 3.8/1
L8	Coil		F 510 - 3.9
R1	Resistor, depos. carbon	12.5 k Ω /2 w	WF 12,5 k/2
R2	Resistor, depos. carbon, variable	2.5 k Ω lin.	WS 9122 F/2,5 k
R3	Resistor, depos. carbon	1.6 k Ω /0.5 w	WF 1,6 k/0,5
R4	Resistor, depos. carbon, variable	1 k Ω lin.	WR 4 F/1 k
R5	Resistor, depos. carbon, variable	5 k Ω lin.	WS 7126/5 k
R6	Resistor, depos. carbon	100 k Ω /0.5 w	WF 100 k/0,5
R7	Resistor, depos. carbon	5 M Ω /0.5 w	WF 5 M/0,5
R8	Resistor, depos. carbon	10 M Ω /0.5 w	WF 10 M/0,5
R9	Resistor, depos. carbon	5 M Ω /0.5 w	WF 5 M/0,5
R11	Lamp, glow, miniature	220 v	RL 210

Ref. No.	Designation	Ratings	R&S Stock No.
Rö1	Duo-triode		6 SN 7
Rö2	Duo-diode		6 H 6
S1	Switch, wafer		SRN 3351/32
S2	Switch		according to F 510 Bl. 2
S3	Fuse strip		FD 603/2
S4	Switch, toggle		SR 122/3
Si1	Fuse	100 ma	0,1 C DIN 41571
Tr1	Transformer, power		F 610 - 4.2

Guarantee

Rohde & Schwarz guarantee

F O R O N E Y E A R

each instrument manufactured and sold by them to be free from defects in material and workmanship, subject to clause 5 of their terms of delivery and payment.

This guarantee does not imply the right to rescind a sale or demand a reduction in purchase price. The firm's obligation under this guarantee is limited to the repair or replacement of the defective part or parts, provided the claim is asserted in writing immediately, or within one week at the latest, after discovery of the defect. The part or parts shall be returned to the factory, with transportation charges prepaid, within one week from the instruction by the firm to do so. The return charges shall likewise be covered by the purchaser. The firm does not assume any liability for damage resulting directly or indirectly from the defect. The guarantee shall be void if the part or parts have been tampered with.

The seals of the instrument shall be undamaged. Rohde & Schwarz guarantee valves for which the purchaser has not received the certificate of guarantee of the manufacturer. Defective valves which are held to be covered by this guarantee shall be returned to the factory for examination. The following details shall be specified:

Number, date and reference of the invoice;
type and serial number (Fnr.) of the instrument;
specification of valve defect.

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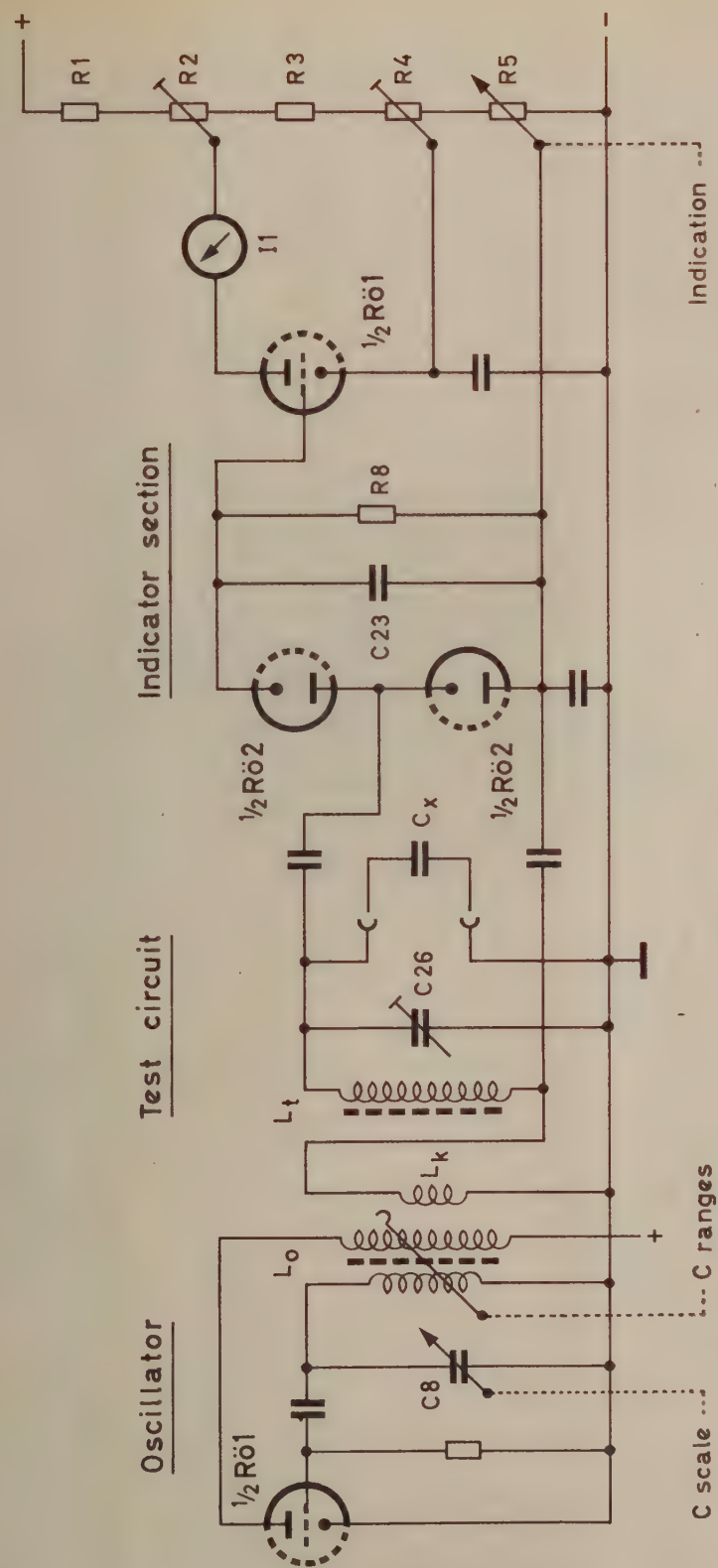
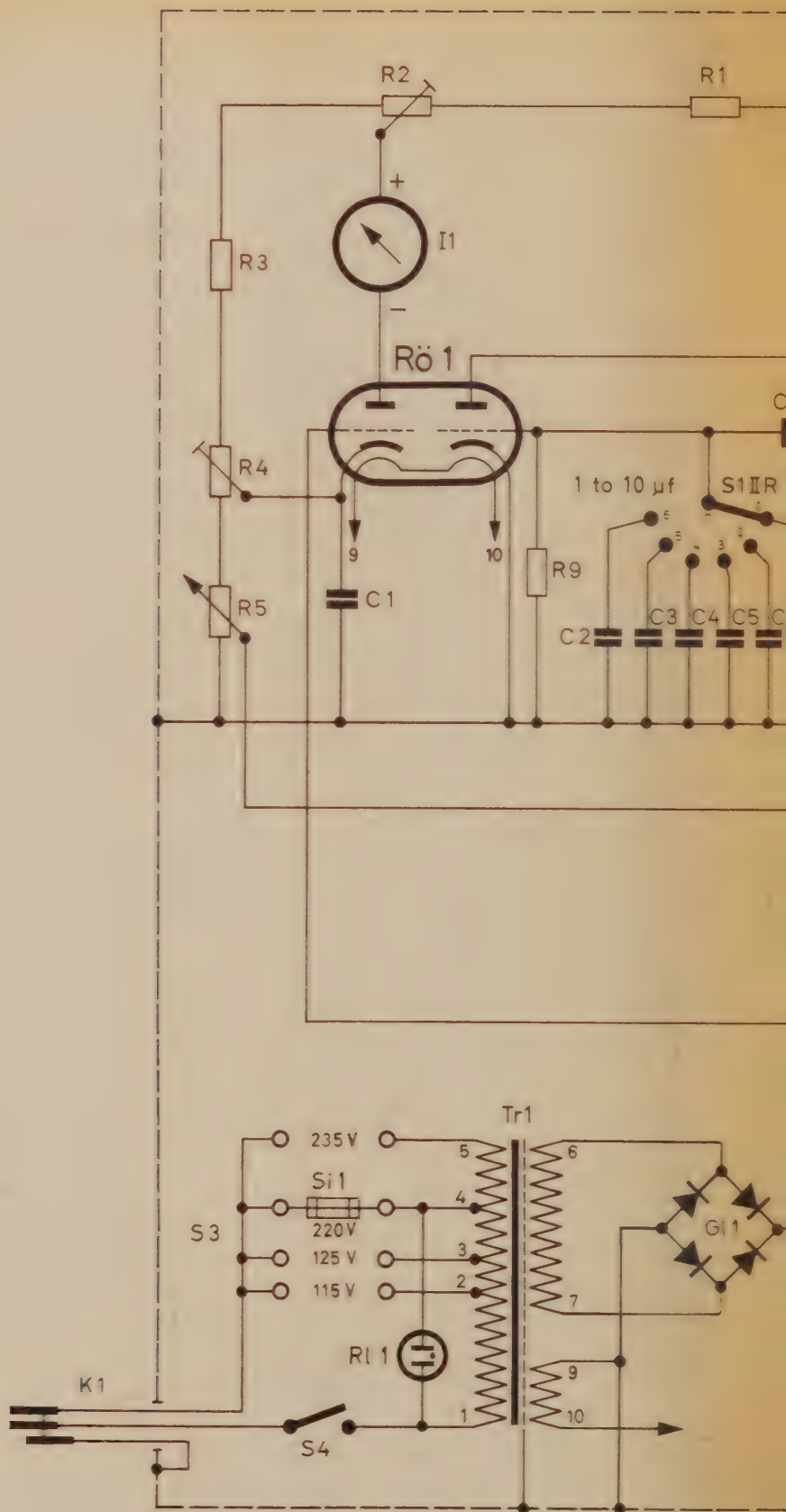
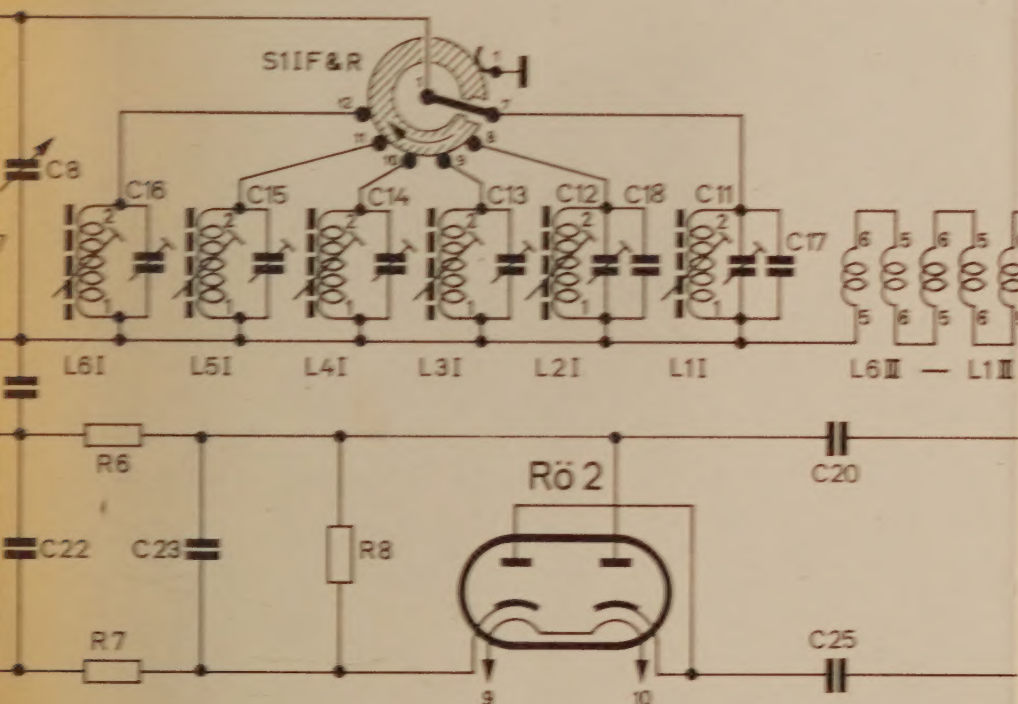
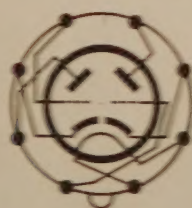


Fig. 1 Simplified circuit diagram of the Capacitance Meter Type KARU

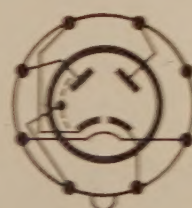


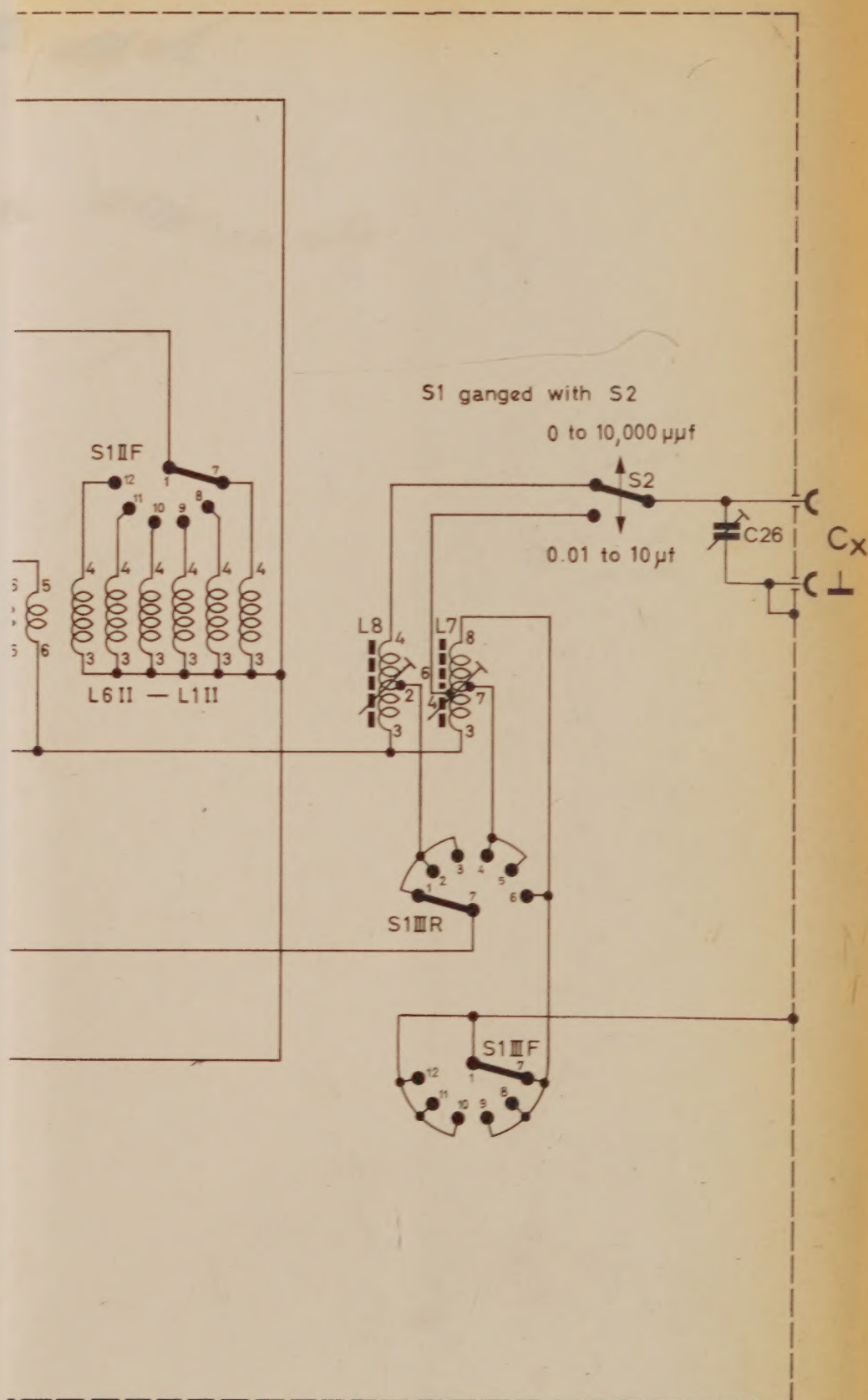


Rö1
6SN7



Rö2
6H6





Circuit diagram of
Capacitance Meter
 Type KARU BN 510

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